

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 :  C09K 7/06		A1	(11) International Publication Number: WO 95/26386  (43) International Publication Date: 5 October 1995 (05.10.95)
<p>(21) International Application Number: PCT/GB95/00680</p> <p>(22) International Filing Date: 24 March 1995 (24.03.95)</p> <p>(30) Priority Data: 9406057.1 26 March 1994 (26.03.94) GB</p> <p>(71) Applicant (for all designated States except US): HERIOT-WATT UNIVERSITY [GB/GB]; Riccarton, Edinburgh EH14 4AS (GB).</p> <p>(72) Inventors; and</p> <p>(73) Inventors/Applicants (for US only): WILKINSON, Alastair, Ord [GB/GB]; 97 Forrester Road, Edinburgh EH12 8AQ (GB). GRICSON, Stephen, John, Wentworth [GB/GB]; 48 Thomson Crescent, Currie, Midlothian EH14 5JS (GB). TURNBULL, Robert, William [GB/GB]; 8 River Walk, Dalgety Bay, Fife KY11 5YF (GB).</p> <p>(74) Agents: McCALLUM, William, Potter et al.; Cruikshank &amp; Fairweather, 19 Royal Exchange Square, Glasgow G1 3AE (GB).</p>		<p>(81) Designated States: AM, AT, AU, BB, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LU, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TT, UA, UG, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TO), ARIPO patent (KE, MW, SD, SZ, UG).</p> <p>Published With international search report.</p>	
<p>(54) Title: DRILLING MUD</p> <p>(57) Abstract</p> <p>The present invention relates to an invert emulsion drilling mud having a continuous oil phase substantially free of mineral oil; a disperse aqueous phase; emulsifier means; weighting agent means. In one aspect of the invention the oil phase consists essentially of a natural triglyceride ester oil which oil has a substantially reduced gum content. In another aspect the oil phase consists essentially of a natural triglyceride ester oil and a non-toxic biodegradable viscosity reducing diluent, said emulsion has a pH which is not strongly alkaline and is substantially lime-free, and said emulsifier means is effective under not strongly alkaline substantially lime-free conditions.</p> <p><i>112 50, 51, 53-55 57, 56, 85 50, 51: 52: 54, 55, 85 52: 58 ALLOU 56</i></p> <p><i>14, 18-20</i></p>			

BEST AVAILABLE COPY

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Beira	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KZ	Kenya	RO	Romania
CA	Canada	KG	Kyrgyzstan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

- 1 -

DRILLING MUD

The present invention relates to drilling muds and more particularly drilling muds suitable for use in drilling for the exploitation of oil and/or natural gas in off-shore and  
5 other environmentally sensitive situations.

It has previously been proposed to use natural animal and vegetable oils in drilling fluids. As discussed in US-A-5,232,910 though such previous proposals suffered from substantial disadvantages including high viscosity and  
10 hydrolysis of the oil component by the alkaline components e.g. lime ( $\text{Ca}(\text{OH})_2$ ) used in drilling fluids in order to, inter alia, prevent corrosion. US-A-5,232,910 seeks to avoid these problems by avoiding the inclusion of the triglyceride esters which normally constitute such  
15 animal/vegetable oils, and using instead monofunctional alcohol esters generally obtained by chemical modification of the oils comprising hydrolysis of the natural oils, separation of the acid components, and re-esterification thereof with suitable alcohols. This additional processing  
20 is however inconvenient and can result in additional expense.

It is an object of the present invention to avoid or minimize one or more of the above disadvantages.

It has now surprisingly been found that natural triglyceride  
25 ester oils with relatively high viscosity can be satisfactorily used in drilling fluids with minimal hydrolysis problems if suitable diluents are included to reduce viscosity and provided that the emulsion is substantially lime-free, and that highly alkaline conditions  
30 are avoided and/or substantially unrefined vegetable oils are avoided.

The present invention provides an invert emulsion drilling mud having a continuous oil phase substantially free of mineral oil; a disperse aqueous phase; emulsifier means;  
35 weighting agent means; characterised in that: said oil phase

- 2 -

consists essentially of a natural triglyceride ester oil which oil has a substantially reduced gum content.

- As discussed further hereinbelow, natural triglyceride ester oils contain considerable amounts of gums e.g. up to around 5% v/v or more and we have found that if the gum content of such oils is substantially reduced e.g. to 2% v/v or less, then the undesirable hydrolysis of the oils can be substantially reduced or avoided..

- The present invention further provides an invert emulsion  
drilling mud having a continuous oil phase substantially  
free of mineral oil; a disperse aqueous phase; emulsifier  
means; weighting agent means; characterised in that: said  
oil phase consists essentially of a natural triglyceride  
ester oil which has been substantially degummed and a non-  
toxic biodegradable viscosity reducing diluent, said  
emulsion has a pH which is not strongly alkaline and is  
substantially lime-free, and said emulsifier means is  
effective under not strongly alkaline substantially lime-  
free conditions.

The present invention also provides an invert emulsion  
drilling mud having a continuous oil phase substantially  
free of mineral oil; a disperse aqueous phase; emulsifier  
means; weighting agent means; and preferably fluid loss  
inhibition means, characterised in that: said oil phase  
consists essentially of a natural triglyceride ester oil and  
a non-toxic biodegradable viscosity reducing diluent, said  
emulsifier means is effective at substantially non-alkaline  
pH, and said emulsion has a substantially non-alkaline pH  
and is substantially lime-free.

We have found that hydrolysis of the vegetable oil leading  
to loss of performance can be substantially avoided or at  
least restricted to acceptable levels if the mud is made  
substantially lime-free and excessively alkaline or acid  
conditions are avoided. Drilling muds traditionally contain  
substantial amounts of lime and thus are more or less highly

- 3 -

alkaline (pH greater than 13), in order to avoid corrosion. Surprisingly we have found, though, that corrosion is not, in practice, a significant problem with drilling muds which are entirely lime-free and even mildly acidic, though as 5 further discussed hereinbelow, hydrolysis can be contained to acceptable levels even when up to around 0.14%, w/v of lime is present corresponding to pH values of around 12.5 in the aqueous phase; provided more or less highly refined vegetable oil is used. When less refined grades of oil are 10 used then a less-alkaline pH should be used.

In accordance with the present invention the oils used are substantially degummed i.e. more than 50% v/v of the gum content has been removed. Preferably the oils used are at least of super-degummed grade as used in chemical 15 manufacturing. Advantageously the oils are of a substantially fully refined grade which is more or less readily available e.g. as so-called "edible-grade" oil. In general the greater the degree of refinement, the greater the reduction in susceptibility to hydrolysis that can be 20 achieved. In practice we have found that crude unrefined vegetable oils can contain up to around 5% v/v or more of non-glyceride components or so-called gums which are multicomponent mixtures containing such things as phosphate esters, sterols, triterpene alcohols, fatty alcohols, waxes 25 and minerals, which have the potential to act as surface-active agents and thereby influence the rapeseed oil hydrolysis process; itself an interfacial phenomenon. Thus in accordance with the present invention there is preferably used a vegetable oil containing not more than 2%, most 30 preferably not more than 0.5%, advantageously not more than 0.25%, v/v of gums.

Suitable combinations of pH, lime content, and gum content in the vegetable oil (i.e., degree of refinement) can be readily determined by simple trial and error. In general 35 there may be used a pH in the range from 4 to 12.5, preferably from 5 to 12, advantageously from 6 to 11.

- 4 -

Thus with a drilling mud of the present invention it is possible to provide environmentally acceptable drilling muds based on readily available natural triglyceride ester oils, which muds have operating characteristics and performance 5 comparable to those of previously known drilling muds, and which are reasonably stable under normal operating conditions.

Particularly suitable natural triglyceride ester oils that may be mentioned include vegetable oils which are 10 triglyceride esters of long-chain (12 to 24 carbon atoms), saturated or preferably unsaturated, carboxylic acids of the type commonly described as fatty acids, which are liquid at standard temperature and pressure. Particularly suitable vegetable oils include rapeseed, olive, sunflower, peanut, 15 palm kernel, grape seed, safflower and corn oils.

In general the relative amounts of the principal components, that is the oil phase, water phase, weighting agent etc. are comparable to those in conventional drilling muds. Thus the oil phase will generally comprise from 20 to 99, e.g. 20 to 20 80, advantageously from 35 to 99, preferably from 50 to 99% v/v of the drilling mud and the dispersed water phase from 0 to 80%, preferably 0 to 50%, desirably from 0 to 20, most preferably from 0 to 10, e.g. 2 to 10, advantageously from 3 to 8% v/v. The weighting agent is generally used in an 25 amount of from 0 to 40% v/v, depending upon the requirements of the drilling conditions encountered and the remaining components usually do not exceed 10, generally 3 to 5%, v/v of the drilling mud.

In order to bring the viscosity of the oil phase down to an 30 operationally suitable level, generally not more than 30cSt, preferably not more than 15cSt, at 40°C, there is used a suitable viscosity reducing diluent. Desirably this has a relatively high flash point; preferably not less than 65°C, advantageously not less than 70°C, most preferably not less 35 than 100°C, and a viscosity of not more than about 10cSt at 40°C. Suitable diluents include medium length hydrocarbon

- 5 -

chain alcohols, and ethers and esters based on medium length hydrocarbon chain alcohols. As used herein the expression "medium length" hydrocarbon chain generally indicates C<sub>5</sub> to C<sub>15</sub>. Preferably there are used diluents wherein the 5 "alcoholic" hydrocarbon chain length is from C<sub>6</sub> to C<sub>10</sub>, e.g. C<sub>8</sub>. Specific diluents of this type that may be mentioned include:

- Esters: 2-ethylhexyl acetate, di-2-ethylhexyl adipate, or 2-ethylhexyl oleate;  
10 Ethers: dipropylene glycol monomethyl ether, di-isodecyl ether or di-octylether; and  
Alcohols: octan-2-ol

We have also found that aliphatic hydrocarbons are particularly convenient for use in the drilling muds of the 15 invention. Hydrocarbons which have suitably high flash points and low viscosity as indicated above include linear alpha-alkenes having a hydrocarbon chain length of from C<sub>5</sub> to C<sub>22</sub>, preferably from C<sub>11</sub> to C<sub>18</sub>. Although branched chain hydrocarbons are less preferred, they may be used provided 20 they are substantially free of short chain (generally less than C<sub>6</sub>) branches.

The diluent, and indeed the various other additives, should also, at least when in combination with the other components in the drilling mud, be non-toxic and environmentally 25 acceptable. Non-toxicity and acceptability are conveniently evaluated by means of the so-called PARCOM Tests established by the Paris Commission which establish standards for low toxicity and low bioaccumulation, and low persistence i.e. biodegradation, as follows:

- 30 1. Toxicity is determined for three categories of marine organism:  
\*primary producers (72 h test using the marine single-celled alga *Skeletonema costatum*)  
\*herbivore (48 h test using the marine crustacean copepod  
35 *Acartia tonsa*)  
\*sediment dweller (10 day test using the marine amphipod

- 6 -

*(Corophium volutator)*

The first two tests estimate the hazard of the drilling mud in the water column, while the third, as the name suggests, estimates the hazard of the material in the sediment (which 5 is the primary environmental fate compartment for discharged solid waste). Few current drilling muds exhibit significant water column toxicity, and consequently evaluation often rests on the results of sediment toxicity tests. The first two tests estimate short-term (acute) toxicity and require 10 the drilling mud to be non-toxic at drilling mud concentrations up to 1000 mg/l of water.

For products which are of acceptably low acute toxicity, there may nevertheless still be a residual concern about the potential of the base fluid for bioaccumulation and long- 15 term toxic effects.

2. Bioaccumulation concerns are addressed by the estimation of the octanol-water partition coefficient, generally using the OECD 117 guideline for HPLC determination. In cases where it is believed that this measurement may overestimate 20 bioaccumulation potential, a direct measurement of bioaccumulation may be carried out using the marine mussel *Mytilus edulis*.

3. Biodegradability and the potential persistence of drilling mud components (in particular, the base fluid in 25 invert emulsion systems) are addressed by measurements of aerobic and anaerobic degradation. These tests are conducted in accordance with a number of OECD and ISO guidelines, and at present require a minimum of 60% degradation within the test period (28-56 days) in order to 30 be considered 'readily' degradable.

Evidence of ready aerobic degradability (i.e. amenability to oxidative metabolism) can be used in conjunction with the results of *Mytilus* bioaccumulation tests (in particular, the rate of base fluid depuration from tissue) to provide a good

- 7 -

indication of the extent to which a base fluid is likely to be significantly accumulated through the food chain.

The amount of diluent used may be varied within relatively wide limits depending on inter alia the desired drilling mud viscosity and the viscosity of the individual natural oil(s) used therein. In general there may be used from 5 to 60%, preferably from 10 to 50%, advantageously from 25 to 40 e.g. about 25%, v/v of diluent in the oil phase.

In addition to the reduction of the high viscosity due to 10 the vegetable oil component, we have also found that the diluent used can additionally lead to a significant reduction in hydrolysis of the triglyceride ester. This affords a useful degree of flexibility in relation to other parameters of the drilling muds of the invention, for 15 example, to allow the inclusion of small lime concentrations up to say 0.14% w/v, and/or reduction of the degree of refinement of the vegetable oil e.g. allowing the use of vegetable oils containing up to 3% v/v of gums.

In general the various additives used should be compatible 20 with and/or capable of functioning effectively under substantially non-alkaline conditions.

Various suitable substantially non-alkaline capable emulsifier means are known in the art including oleophilic fatty acid salts such as those based on amido amines of the 25 general formula NZ, wherein Z represents RCONH(CH<sub>2</sub>)<sub>n</sub> - where R is a long chain hydrocarbon, generally C8 to C24 and other amido amines of the general formula NHZX wherein Z has the same meaning as before and X is, for example, ethoxylate. Generally these are used with a suitable carrier or solvent 30 such as a glycol ether. A typical commercially available product is Interdrill Emul HT (Trade Mark) from the Schlumberger Dowell Company of London, England. Other suitable emulsifiers that may be mentioned include alkylbenzene sulphonates and imidazolines.

- 8 -

Suitable weighting agents known in the art are heavy metal minerals such as those based on barium e.g. barite, or iron e.g. haematite. In general these are used in an amount sufficient to increase the specific gravity of the mud to 5 from 1.0 to 2.5 g/cm<sup>3</sup>, and are generally used in an amount of from 5 to 30% v/v in the mud.

Various "activity" control means are known in the art for preventing loss of the aqueous phase into the rock strata through which drilling is taking place, and include alkali 10 or alkaline earth metal salts such as CaCl<sub>2</sub>, NaCl, and KCl.

Provided they are not otherwise specifically excluded from the drilling muds of the present invention, any other additive conventionally used in drilling muds may be included in the drilling muds of the present invention.

15 Thus for example there may be used a viscosity control or thickening agent such as an organophilic clay e.g. an organically treated smectite clay such as that available under the Trade Name: "Interdrill Vistone" from Schlumberger Dowell of London, England, or finely divided bentonite.

20 Also there may be used an oil wetting agent to improve the oil wettability of the inorganic weighting material and other solid material present in the drilling fluid.

Suitable agents include one or more of an alkyl benzene sulphonate and a fatty imidazoline salt. A suitable 25 commercially available product is Interdrill OW (Trade Name) available from Schlumberger Dowell Ltd. of London, England.

Further preferred features and advantages of the present invention will appear from the following examples given by way of illustration.

30 Examples 1 to 3 - Preparation of Drilling Muds

Invert drilling muds were prepared using a natural (i.e. not chemically modified) triglyceride ester rapeseed oil which had the following composition: 61% mono-unsaturated (predominantly oleic); 31% polyunsaturated (predominantly linoleic) and 8% saturated fatty acids. The oil used had 35

- 9 -

been partially refined and was of super-degummed grade with a gum content of approximately 2% v/v.

The oil was mixed with the emulsifier: Emul HT; the oil-wetting agent: Interdrill O/W; and the organophilic clay: Vistone. Calcium chloride was dissolved in water and the resulting brine added to the stirred oil mixture. The resulting emulsion was stirred for approximately five minutes before barite was added, and the complete mixture was then stirred for a further 30 minutes. The maximum temperature of the mixture was controlled by the use of a water bath and was limited to 60-70°.

Three different muds were prepared with different proportions of the above components as set forth in Table 1 hereinbelow:

15 Table 1

Component	Quantity (g/lab barrel)		
	Formulation 1	Formulation 2	Formulation 3
Rapeseed Oil	250.0	187.0	167.2
Oil-wetting Agent	1.0	1.0	1.0
Emulsifier	3.0	3.0	3.0
Organophilic Clay	7.8	7.8	7.8
Water	25.7	25.7	26.3
Calcium Chloride	10.0	10.0	12.2
Diluent	nil	55.5	50.8
Barite	120.3	120.3	256.7
Specific Gravity	1.2	1.2	1.5

#### Examples 4 to 6 - Performance of Drilling Muds

The performance capabilities of the drilling muds of Examples 1 to 3 were assessed as follows: The prepared muds were hot rolled at 120°C for sixteen hours and characterised using 30 the API (American Petroleum Institute) Recommended Practice for the evaluation of oil-based drilling muds: 13B-2. This

- 10 -

relates to a practical situation in which drilling mud may remain in situ in a drill hole for up to 16 hours during a drill bit change.

Further samples of the formulations were subjected to a prolonged hot rolling period of seventy two hours and recharacterised to demonstrate the substantial stability and resistance to hydrolysis of the drilling muds of the invention. The results are summarised in Table 2 hereinbelow.

10 Table 2

	Rheological Property	FORMULATION 1			FORMULATION 2			FORMULATION 3		
		Fresh	Hot Rolled 16 hours	Hot Rolled 72 hours	Fresh	Hot Rolled 16 hours	Hot Rolled 72 hours	Fresh	Hot Rolled 16 hours	Hot Rolled 72 hours
	Apparent viscosity (cP)	80	78.5	58.5	45	47.5	42	66.5	59	66
15	Plastic Viscosity (cP)	71	67	51	38	41	35	52	46	53
	Yield Points (lb/100ft <sup>2</sup> )	18	23	15	14	13	14	29	26	25
	10 sec gel	10	10	6	7	8	6	13	14	12
20	10 min gel	12	11	7	9	9	7	15	16	14
	Electrical Stability (volts)	1574	1610	>2000	1964	1666	>2000	>2000	>2000	>2000

As may be seen from the above Table, the electrical stability remained well above 1000 volts throughout indicating good stability of the emulsion and resistance to de-emulsification of the oil-water emulsion. The gel strength (resistance to settling out of weighting agent and drill cuttings) was also substantially preserved even after the extended hot rolling test.

SUBSTITUTE SHEET (RULE 26)

- 11 -

Example 7 - Effects of Diluents on Partly Degummed (2% gum) Rapeseed Oil

Table 3:

	Diluent	Concentration (lb/barrel)	Percentage Triglyceride Hydrolysis After Hot Rolling (120 °C, 72 Hours)
5	Diluent-free	0	50.8%
	Octan-2-ol	57.1	40.0%
	Dipropylene glycol Monomethyl ether	66.2	42.6%
	Di-iso-decyl ether	57.8	50.9%
10	2-Ethylhexyl acetate	60.3	38.5%
	Di-2-ethylhexyl Adipate	64.7	40.8%

\* Equivalent to 25% v/v of rapeseed oil present in the drilling mud formulation.

15 Example 8 - Effect of Gum Content on Rapeseed Oil Hydrolysis

The effect of added gum on the hydrolysis of a drilling mud based on edible grade rapeseed oil (containing less than 0.2 % gum) with the composition shown in table 4 is shown 20 in Table 5 from which it may be seen that hydrolysis increases dramatically with increasing gum content.

- 12 -

TABLE 4

Component	Concentration (lb/barrel)
Edible Grade Rapeseed Oil	187.0
2-Ethylhexyl Acetate	55.5
Emul HT	3.0
Vistone	7.8
Water	25.7
CaCl <sub>2</sub>	12.2
Barite	120.3

10 TABLE 5

Gum Content (lb/barrel)	Percent Triglyceride Hydrolysis After Hot-Rolling (120 °C., 72 Hours)
0	6.7%
5	14.9%
15	28.5%

Example 9 - Use of Hydrocarbon Diluent in Drilling Mud

The effect of using of different amounts of hydrocarbon diluent commercially available under the Trade Name Ultidrill on triglyceride hydrolysis of an edible grade rapeseed oil based drilling mud, is shown in Tables 6 and 7. In the case of samples 2 and 3, an alternative organophilic clay Truvis (also available from Schlumberger-Dowell), which is effective at lower concentrations, was used in place of Vistone. A conventional fluid loss additive, Truflo MVO (available from Schlumberger-Dowell), was also included to inhibit loss of drilling fluid into the drilled formation.

- 13 -

TABLE 6

Component	Quantity (lb/barrel)		
	Sample 1.	Sample 2	Sample 3
Edible Rapeseed Oil	187.1	132.5	130.2
Ultidrill	53.4	62.1	61.1
Interdrill OW	1.0	1.0	1.0
Emul HT	3.0	6.0	6.0
Vistone	7.0	nil	nil
Truvise	nil	2.0	4.0
Truflo HVO	2.0	3.0	3.0
Water	26.0	25.29	25.17
CaCl <sub>2</sub>	12.2	7.35	7.31
Barite	127.5	348.0	350.4

Table 7

Sample 1

Sample 2

Sample 3

Rheological Properties	BHR	*AHR	BHR	*AHR	BHR	*AHR
Apparent Viscosity (cP)	43.5	39.5	75	85	63	66
Plastic Viscosity (cP)	36	35	61	69	54	53
Yield Point (lb/100 ft <sup>2</sup> )	15	9	28	32	18	26
Fann 6 rpm reading	8	6	16	18	15	14
10 second gel	9	5	16	16	15	12.5
10 minute gel	12	6	20	18	20	15
Electrical stability (volts)	1453	1609	>2000	1353	>2000	1651
Triglyceride Hydrolysis (%)	nil	6.8	nil	10.4	nil	10.3

BHR - Before Hot-Rolling

AHR - After Hot-Rolling

\* - Hot-rolling at 120 °C, 72 hrs.

SUBSTITUTE SHEET (RULE 26)

- 14 -

Example 10 - Lime Tolerance of Substantially Decarburred  
Rapeseed Oil Drilling Mud

The tolerance of edible grade Rapeseed Oil based Drilling mud with the composition shown in Table 8, to increasing amounts of added lime, is shown in Table 9 from which it can be seen that triglyceride hydrolysis is limited to acceptable levels at added lime levels of up to around 0.4 lb/barrel after hot-rolling for 72 hours at 120°C. A conventional fluid loss additive Truflo 100 (similar to Truflo MVO in Example 9) was also included in the drilling mud.

Table 8

	Component	Quantity (lb/barrel)
	Edible Grade Rapeseed Oil	130.3
15	Ultidrill	61.0
	Emul HT	6.0
	Interdrill FL	1.0
	Truflo 100	3.5
	Truvis	4.0
20	CaCl <sub>2</sub>	7.31
	Water	25.71
	Barite	350.4

Table 9

Rheological Property	Quantity of Linn Added to Each Sample (lb/Barrel)									
	0	0.1	0.2	0.3	0.4	0.5	1.0			
BHR	AHR	RHR	AHR	BHR	AHR	BHR	AHR	BHR	AHR	
Apparent Viscosity (cP)	69.5	77.	63	73	69.5	71	70	68.5	70	68.5
Plastic Viscosity (cP)	56	61	57	60	56	55	56	54	58	56
Yield Point (lb/100 ft <sup>2</sup> )	27	32	24	30	27	32	28	29	27	32
Fann 6 rpm Reading	17	18	14	16	16	17.5	16	16	16	16
10 second gel	17	17	14	15	16	16	16	15.5	14	15
10 minute gel	20	20	18	18	20	19	21	18	19	18
Electrical Stability (volts)	2000	1534	2000	1621	2000	1791	2000	1738	2000	1796
Triolein/oleic acid Hydrolisis %	nil	10.4	nil	12.8	nil	10.2	nil	9.7	nil	16.9

BHR Before Hot-Rolling   AHR After Hot-Rolling

- 16 -

CLAIMS

1. An invert emulsion drilling mud having a continuous oil phase substantially free of mineral oil; a disperse aqueous phase; emulsifier means; weighting agent means;
- 5 characterised in that: said oil phase consists essentially of a natural triglyceride ester oil which oil has a substantially reduced gum content.
- 10 An invert emulsion drilling mud having a continuous oil phase substantially free of mineral oil; a disperse aqueous phase; emulsifier means; weighting agent means; characterised in that: said oil phase consists essentially of a natural triglyceride ester oil and a non-toxic biodegradable viscosity reducing diluent, said emulsion has a pH which is not strongly alkaline and is substantially 15 lime-free, and said emulsifier means is effective under not strongly alkaline substantially lime-free conditions.
- 20 3. A mud according to claim 2 wherein said oil is at least partly degummed.
4. A mud according to claim 1 or claim 3 wherein said oil has a gum content of not more than 2% v/v.
- 25 5. A mud according to claim 4 wherein said oil has a gum content of not more than 0.5% v/v.
6. A mud according to claim 4 wherein said oil is of an edible-grade.
- 25 7. A mud according to any one of claims 1 to 6 which contains not more than 0.14% v/v of lime.
8. A mud according to any one of claims 1 to 7 which has a pH value of not higher than 12.5.
- 30 9. A mud according to claim 8 which has a pH value in the range from 4 to 11.

- 17 -

10. A mud according to any one of claims 1 to 9 wherein said diluent has a flash point not lower than 65°C.

11. A mud according to any one of claims 1 to 10 wherein said diluent has a viscosity of not more than 10cSt at 40°C.

5 12. A mud according to any one of claims 1 to 11 wherein said diluent is selected from aliphatic hydrocarbons, aliphatic hydrocarbon alcohols, and ethers and esters of aliphatic hydrocarbon alcohols.

13. A mud according to claim 12 wherein the diluent 10 comprises a saturated or unsaturated hydrocarbon having a hydrocarbon chain length of from C<sub>10</sub> to C<sub>22</sub>.

14. A mud according to any one of claims 1 to 13 which contains from 5 to 60% w/w of diluent in the oil phase.

15. A mud according to claim 14 which contains from 25 to 15 40% w/w of diluent in the oil phase.

16. An invert emulsion drilling mud having a continuous oil phase substantially free of mineral oil; a disperse aqueous phase; emulsifier means; weighting agent means; and preferably fluid loss inhibition means, characterised in 20 that: said oil phase consists essentially of a natural triglyceride ester oil and a non-toxic biodegradable viscosity reducing diluent, said emulsifier means is effective at substantially non-alkaline pH, and said emulsion has a substantially non-alkaline pH and is 25 substantially lime-free.

## INTERNATIONAL SEARCH REPORT

International Application No	PCT/GB 95/00680
------------------------------	-----------------

A. CLASSIFICATION OF SUBJECT MATTER IPC 6 C09K7/06
---

According to International Patent Classification (IPC) or to both national classification and IPC
---

B. FIELDS SEARCHED
--------------------

Minimum documentation searched (classification system followed by classification symbols) IPC 6 C09K
---

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
---

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
--

C. DOCUMENTS CONSIDERED TO BE RELEVANT
--

Category *	Character of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP-A-0 374 671 (HENKEL) 27 June 1990  see page 3, line 7 - line 44 see page 3, line 57 - page 5, line 5 see page 5, line 12 - line 37 see page 6, line 16 - line 54 ---	1,2,8,9, 12,16
Y,P	EP,A,0 625 563 (CALGENE CHEMICAL INC.) 23 November 1994  see page 2, line 8 - line 31 see page 3, line 24 - line 30 see page 3, line 48 - line 57 ---	1,2,12, 16 ---

<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C.	<input checked="" type="checkbox"/> Patent family members are listed in annex.
--	--

* Special categories of cited documents :
---

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
---

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
--

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
--

"Z" document member of the same patent family
---

1
---

Date of the actual completion of the international search
---

23 June 1995
--------------

Date of mailing of the international search report
--

03.07.95
----------

Name and mailing address of the ISA European Patent Office, P.B. 5018 Pijnacker 2 NL - 2230 HV Rijswijk Tel. (+31-70) 340-2040, Telex 31 451 epo nl. Fax (+31-70) 340-2016
--

Authorized officer
--------------------

Boulton, A
------------

## INTERNATIONAL SEARCH REPORT

Internat- Application No  
PCT/GB 95/00680

## C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Description of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP-A-0 374 672 (HENKEL) 27 June 1990  see page 3, line 7 - line 29 see page 4, line 38 - line 48 see page 5, line 13 - line 57 see page 6, line 58 - page 7, line 12.	1,2,8,9, 12,16
Y	EP,A,0 382 071 (HENKEL) 16 August 1990  see page 5, line 4 - page 7, line 38	1,2,8,9, 16
Y	EP,A,0 386 636 (HENKEL) 12 September 1990  see page 3, line 4 - line 19 see page 4, line 36 - page 5, line 52 see page 6, line 55 - page 7, line 12	1,2,8,9, 12,16
Y	US,A,4 631 136 (R.W.JONES) 23 December 1986 see column 3, line 32 - column 4, line 35 see column 5, line 52 - column 6, line 3	1

Form PCT/ISA/250 (continuation of second sheet) (July 1992)

## INTERNATIONAL SEARCH REPORT

Internat.	Application No
PCT/GB 95/00680	

Patent documents cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-374671	27-06-90	DE-A- 3842659 AU-B- 639219 AU-A- 4655189 CA-A- 2006010 DE-D- 58907349 WO-A- 9006980 EP-A- 0448579 ES-T- 2061909 US-A- 5232910	28-06-90 22-07-93 10-07-90 19-06-90 05-05-94 28-06-90 02-10-91 16-12-94 03-08-93
EP-A-625563	23-11-94	US-A- 5380469 CA-A- 2118819 JP-A- 7048587	10-01-95 19-09-94 21-02-95
EP-A-374672	27-06-90	DE-A- 3842703 AU-B- 634207 AU-A- 4954990 CA-A- 2006009 WO-A- 9006981 EP-A- 0448646 US-A- 5252554	21-06-90 18-02-93 10-07-90 19-06-90 28-06-90 02-10-91 12-10-93
EP-A-382071	16-08-90	DE-A- 3903784 AU-B- 625325 AU-A- 4957890 CA-A- 2009688 WO-A- 9009416 EP-A- 0457775 JP-T- 4503221 RU-C- 2013436 US-A- 5106516	16-08-90 09-07-92 05-09-90 09-08-90 23-08-90 27-11-91 11-06-92 30-05-94 21-04-92
EP-A-386636	12-09-90	DE-A- 3907392 AU-B- 626118 AU-A- 5180290 WO-A- 9010681 EP-A- 0462152 ES-T- 2052997 JP-T- 4503966 US-A- 5403822	13-09-90 23-07-92 09-10-90 20-09-90 27-12-91 16-07-94 16-07-92 04-04-95

## INTERNATIONAL SEARCH REPORT

Internat.	Application No
PCT/GB 95/00680	

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A-4631136	23-12-86	NONE	

Form PCT/ISA/210 (patent family annex) (July 1997)

page 2 of 2

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**